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FROM WILLIAM ROSSITER
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12 PAGES, INCL. COVER SHEET

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30 May 2001

Donna Wieting
Chief, Marine Mammal Conservation Division
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 20910-3226
FAX: 301-713-0376

Re: Taking and Importing Marine Mammals: Taking Marine Mammals Incidental to Navy Operations of Surveillance Towed Array Sensor System Low Frequency Active Sonar

Dear Ms. Wieting,

Cetacean Society International (CSI) requests that NMFS refuse the application from the U.S. Navy for, and not issue final regulations pertaining to, a "Letter of Authorization (LOA) for the take of small numbers of marine mammals by harassment incidental to Navy operations of the Surveillance Towed Array Sensor System (SURTASS) Low Frequency Active (LFA) Sonar".

In addition, CSI urges NMFS not to proceed with any rule that temporary threshold shift (TTS) be considered only Level B Harassment. The implications of this rule are very significant, and deserve considerable detail and attention. This rule seems intended for all species, all sources, and all regions. Will NMFS confirm that this rule would establish Level A harassment at the theoretical onset of PTS, which, for lack of more data, might be construed to be 10-15 db above the only data about onset of TTS in cetaceans, 192 dB re1µPa (rms) in bottlenose dolphins and belugas. Does this mean that NMFS intends that Level harassment would not be considered to have occurred below a received level of 207 db?

The U.S. Navy first requested this small take exemption, under section 101(a)(5)(A) of the MMPA, in August 1999. CSI has been involved directly with the LFA issue since 1996. The unusual delay to this point enunciates that the LFA process has been extraordinarily complicated. The primary complication is that conclusions have been asserted from inadequate data, decisions are being attempted from erroneous conclusions, and a large number of significant criticisms are being received. The change in this issue and relevant science over time must be recognized and responded to prior to the issuance of the LOA.

One benefit of the lengthy LFA process has been the extraordinary effort, outside of NMFS or the Navy, to better understand the real impact of LFA-type noise in the ocean. NMFS should review this input as a positive addition to human knowledge, not a negative critique of a project that is delaying a process. For example, while the FEIS focuses on hearing loss but almost ignores potential non-auditory impacts, experts from several disciplines have contributed theories, opinions, and facts to explore the significance of resonance. Recent events and research have only begun to illuminate that resonance may be the most significant damage from the LFA and related sources, especially in terms of gross numbers seriously injured animals. If this was an aircraft nearing production, and an equivalent flaw affecting lives was strongly suggested but left unresolved in order to expedite the process, it would be criminal to place the aircraft

Because of the over-reaching significance of this single LOA, CSI is extremely concerned that flaws or inadequacies in the FEIS data and conclusions will be ignored in the interest of expediency, efficiency, and deadlines, and become established in the foundation of all future human noise management in the oceans.

The future of the NMFS's mandated management of anthropogenic acoustical impacts will depend on what the NMFS does with the LFA. As suggested by the proposed rule making, NMFS has accepted that the LFA process is to be taken in context with all human sources contributing to a rapidly growing problem of anthropological acoustical impacts in the oceans. NMFS cannot view this process as dealing just with a single Navy system. Regulations from this issue will become the standard for ocean noise management in the U.S., and by default, worldwide. This LOA and rule making process must be viewed as the last opportunity to create scientifically and legally defensible management policy and rules to preclude the issue becoming mired in court.

It is crucial that NMFS determinations and regulations withstand probable legal challenges. It is unlikely that they will survive if based on the FEIS, and scientific research purportedly used to substantiate it.

NMFS must determine that "the taking will have a negligible impact on the affected species and stocks of marine mammals, will (if appropriate through implementation of appropriate mitigation measures) be at the lowest level practicable, and will not have an immitigable adverse impact on the availability of the species or stock(s) for subsistence uses", over at least the presumed five year authorization period. CSI asserts that NMFS has not examined all of the "best information available", and sufficient gaps in knowledge exist to prevent the NMFS from such a determination. Indeed, the unknowns are so pervasive that CSI notes that the Office of National of National Marine Sanctuaries has asked the Navy to avoid deploying the LFA within the Monterey Bay National Marine Sanctuary.

FEIS:
Although expected, the NMFS acceptance of the LFA Overseas Environmental Impact Statement / Environmental Impact Statement (FEIS) was a perfidious revelation to everyone concerned with anthropogenic acoustical impacts, and the LFA in particular. Many people had contributed significant comments and critiques of the Draft EIS. The answers provided in the FEIS to all commenters demonstrate a range of denials, dismissals, deflections, misstatements, and inaccuracies, with only occasionally an objective and factual response. Many CSI comments or questions were ignored. A sampling from expert comments, such as the MMC's, demonstrated the same tendency. There is still no accurate sound field map of the LFA signal, in spite of NMFS' concern with levels of injury within the "safety zone". The FEIS somehow evades providing the "equivalent source level" for multiple projectors upon which the 180dB isopleth is based, which has been calculated by outside experts as 240.1 dB re1µPa (rms). The potential and specific conditions for exceeding 180dB re1µPa (rms)(180 dB) beyond the 1km mitigation zone is not quantified, nor is that related to mitigation efficiency. The FEIS, with official responses, remains inadequate. It must not be relied upon by NMFS for any management standards or rule making for human noise in the oceans.

By accepting the FEIS NMFS has accepted responsibility for all the FEIS inadequacies, and inadequate responses to useful and important comments. However, whereas the FEIS was written by the contractor, eager to sell the LFA system, and the Navy, anxious to use it, the first responsibility of NMFS is to the conservation of ocean resources, not military needs. The clear links between Navy interests and NMFS decisions, particularly as flaunted against outside expert and public opinion, will continue to fuel a controversy bound to be addressed in a Congressional or legal forum.

For the Administrative Record CSI includes in this comment period on the LOA all previously submitted formal comments relating to the LFA, whether addressed to Joseph Johnson, Marine Acoustics, the Navy, or NMFS. As very few comments were addressed or answered satisfactorily

we consider them unresolved, and now the responsibility of NMFS to answer. CSI is also deferring to others we know to be asking questions of concern to us, rather that including each and every point of contention with the FEIS that we have found. By default NMFS has agreed with them all, adding up to a gross fault.

NAVY FUNDING:
CSI must note also, in agreement with many other observers, that there appears to be a direct relationship between scientists not willing to comment publicly on the LFA, despite their private opinions, and their funding potentials from Navy sources, particularly the Office of Naval Research (ONR). The link between funding and the LFA invites investigation. One immediate example is the recent adjustment of funds from NMFS in support of right whales. After a controversial use of funds by NMFS in 2000, appropriated by Congress specifically to augment survival of the North Atlantic right whale, Congress again allocated millions, but only gave a portion to NMFS, again specifically to support right whale survival. At this writing NMFS has recently changed funding priorities, removing support from the disentanglement program, population studies, and a related scarification project, while allocating a very large sum to at least one other scientist closely related to the LFA.

HEIGHTENED THREAT CONDITIONS:
How can the NMFS make a determination of negligible impact on affected species and stocks of marine mammals without knowing when and how the LFA is used, including the significant percentage of takes from LFA operations under "heightened threat conditions"? The NMFS and FEIS comments to this question misunderstood the point of CSI's comments to both the DEIS and the Notice of Advanced Rule Making.

The FEIS defines the LFA employment only for test, training and military operations not considered "periods of heightened threat conditions", as determined by the National Command Authorities. NMFS has no control over the use of the LFA asset under "heightened threat conditions". Having control is not the same as factoring the effects. It is U.S. Navy policy that many "routine" movements of submarine-related assets are operated as if under "heightened threat conditions". Indeed, since the Cole tragedy, all movements of Navy vessels are classified. The Navy has an estimate for LFA use under such conditions, especially as they may include regularly scheduled events. A direct tasking of an LFA asset by the CNO, for example in support of the routine deployment or retrieval of a ballistic missile submarine, would be a classified operation that could deploy the LFA under "heightened threat conditions", without mitigations or regard for offshore biologically important areas (OBIA). Indeed, routine nuclear submarine transits from New London, for example, may task a LFA asset to operate well inside the 200m isobath, to sweep for enemy attack submarines that are attempting to track and compromise the USN missile submarine. The Navy may not provide NMFS access to data on this or other LFA "heightened threat conditions" operations, but a total, conservative estimate can be provided by the Navy that does not compromise national security. NMFS must establish the significance of LFA takes during "heightened threat conditions", and factor in estimated takes from such operations or admit that all estimates of takes by the LFA are inadequately represented. Although the FEIS can rightly dismiss potential impacts from such conditions, the NMFS cannot.

PRACTICALITY:
NMFS has made several preliminary determinations relating to the LFA based on impracticality, for example specifying migratory corridors. CSI challenges this as inappropriate. By definition it will always be impractical to establish management rules or constraints on anthoropogenic noise, because all solutions will be impractical to someone. NMFS cannot use practicality as an excuse to escape mandated responsibilities. At least "best available" and conservative estimates must be made, and used.

OFFSHORE BIOLOGICALLY IMPORTANT AREAS:

CSI is grateful that NMFS has decided that: "until such time as the Navy provides verifiable test results on the HFM3 sonar, NMFS will need to base its determination of negligible impact solely on the effectiveness of geographic mitigation." This amounts to a LOA based on the LFA operating in the blind, in all but a very small portion of its geographical operating range.

The geographic mitigations, or Offshore Biologically Important Areas (OBIA), are inadequate. If the LOA is approved without significant OBIA additions, especially just to expedite the LOA and rulemaking, it will be self-defeating. NMFS is aware that the review process to implement new OBIA's is typically ponderous, and will not preclude LFA operations in those vulnerable areas for a considerable time. NMFS has declared that: "proposals for designation of areas would not affect the status of LOAs while the rulemaking is in process", which is acceptable if NMFS ensures that the approved LOA includes many appropriate and significant additions beyond the initial selection.

Geographical areas CSI immediately nominates for inclusion as OBIAs include:

- The Gully, off Nova Scotia, defined to include significant areas deeper than the 200m isobath specified in OBIA #1.

- OBIA#1 extended to include the most conservative estimate of the probable feeding grounds of non-Bay of Fundy right whales (see below), and funding appropriate to determine the specific area and probable migrating or transit corridors.

- The 200m isobath surrounding Silver and Navidad Banks, to Hispanola, and enclosing the established migratory corridors of the North Atlantic humpback population without depth limits.

- Major upwelling sites, such as off Africa, India, Gulf of Oman, South America, and the US.

- All IWC whale sanctuaries, and all U.S. National Marine Sanctuaries.

RIGHT WHALES:
With reference to the OBIA #1 change, above, NMFS should certainly agree, as the Navy does, that the North Atlantic right whale population is extremely vulnerable, and that any and all means should be used to prevent any further population decay. NMFS has imposed, or is considering, fisheries gear modification, area closures, shipping constraints, whale watch guidelines and other actions, all of which are extremely impractical to the operators. The Navy created what became OBIA #1 very early in the LFA process, specifically to preclude controversial impacts on right whales. Newer information suggests that the specified area isn't large enough.

How can the NMFS make a determination of negligible impact on right whales without knowing where they are? While NMFS will consider only LFA geographical mitigations, pending validation of the HF/M3 Sonar, NMFS cannot ignore the lack of geographical mitigation for 20-30% of feeding North Atlantic (NA) right whales. The NA right whale population's recent calving success should not obscure the reality that almost all calves in recent years were born to mothers that do not feed in the Gulf of Maine or the Bay of Fundy (BOF). These historically more successful non-BOF mothers represent 20-30% of the reproductively active right whale females. Their summering range is unknown, but almost certainly not within the 200m isobath of Offshore Biologically Important Area #1. Their migration route to this area is unknown. The number of males and young calves utilizing this unknown feeding area is also unknown. Should the potential for LFA impacts on this seasonal but significant population be ignored because an immediate solution is impractical?

CSI has extraordinary concerns that LFA operations outside of OBIA#1 will take even one right

The Navy also agrees that visual mitigations, even for this large whale, deserve no more than a 5% rating. The SACLANT report did not verify the efficiency of visual mitigations, even for large cetaceans. No one in their right mind would rely on the passive monitoring to reliably detect right whales. Anyone following the ship-strike issue knows that right whales just don't seem to avoid approaching vessels or danger. If geographic limits are all we can count on, what will happen to all those right whales that are outside of limited areas?

THE 180 dB RULE:
The entire premise, now "believed" by NMFS, is that 180dB re1µPa (rms) (180 dB) is the only threshold of concern. Any value below this received level (RL) is ignored, as are all behavioral impacts not immediately linked on a short-term basis to survival or reproduction in a significant percentage of a population. It is the single most significant factor in the entire management regime for anthropogenic acoustical impacts. In the opinion of many experts not associated with the LFA or NMFS the 180 dB mitigation threshold is arbitrary and indefensible under either scientific peer review or legal definitions.

Although the 180 dB mitigation threshold is asserted in the FEIS, many experts not associated with the LFA refute it. The MMC has commented that no experiments had been done to verify the LFA "scientific team's" establishment of a "threshold for risk of harm for a single ping at 180 dB RL". 180 dB is NMFS' Maginot line, a scientifically unverified, non-peer reviewed value disputed by a great number of experts. CSI challenges NMFS to substantiate this belief in the 180 dB threshold.

With regard to the right whale discussion, above, there is no evidence that an LFA signal will not take a right whale at RLs below 180 dB. The LFA can operate in any OBIA so long as the equivalent source level is <180 dB. Right whale ship-strike data alone suggests that the LFA asset could transmit while sailing right over a right whale. This species simply doesn't react appropriately to ships and other dangers. The species behavior, acoustical range, and critically vulnerable population numbers make it a special case for the LFA issue. This LOA and rulemaking are inadequate to protecting the NA right whale, per NMFS's related mandate.

With regard to the 180 dB "safety zone", NMFS stated, responding to FEIS Comment 20, "NMFS does not agree that the proposed incidental takings would result in more than minimal levels of serious injury. Because serious injury is unlikely to occur unless a marine mammal is well within the 180 dB SURTASS LFA sonar safety zone and close to the source, and because the closer the mammal is to the vessel, the more likely it will be detected, and the SURTASS LFA sonar operation suspended, the potential for serious injury to occur is minimal." Why does NMFS focus on "serious injury", assumed as PTS, whereas the Marine Mammal Commission (MMC) and many experts have declared that behavioral impacts of biological significance to reproduction and survival cannot be ruled out as results to LFA exposure well below a RL of 180 dB? Because, according to NMFS statements, these biologically significant impacts cannot be observed over a short term, cannot be mitigated, cannot be quantified as reliable data, but most of all, cannot be considered without delaying the deployment of the LFA. What precedent is there for NMFS to place the needs of this military system over the needs of marine animals?

NMFS's mandate is to ensure that "the taking will have negligible impact on the affected species and stocks of marine mammals, will be at the lowest level practicable, and will not have an immitigable adverse impact on the availability of the species or stock(s) for subsistence uses". Why does NMFS believe that a received level (RL) of 180 dB is an adequate threshold of LFA mitigation to satisfy this mandate? The NMFS reply to Comment 23 states that: "While the commenter is correct that behavioral modifications can be expected at lower SPLs, the proposed monitoring (visual, passive acoustic and active acoustic), is not likely to be as effective at the greater distances where these impacts are likely to occur. As a result, NMFS prefers to require the Navy to concentrate monitoring in an area wherein marine mammals are more likely to incur an injury". NMFS excludes "behavioral modifications" biologically significant to reproduction and

survival, because they can't be observed. In other words, if the effects of the LFA are too far away or too long term for effective monitoring, only those effects that might be measurable are worth considering.

NMFS / NAVY LINK?:
Many NMFS statements provide examples of the blatant and exploitive link between specific Navy and NMFS people to implement the LFA. In response to Comment 24 NMFS "concurs with the U.S. Navy that in order for training to be effective it must simulate, to the greatest extent practicable, conditions that would be expected during periods of heightened readiness". As a military force the Navy is correct to use the analogy that, "to make an omlette you must break some eggs". NMFS is not a military force.

CSI believes that the following statement has the potential to reduce the entire LFA process to a travesty: "NMFS does not believe the MMPA requires a delay in the issuance of an authorization until mitigation or alternative technology proves effective (as long as a negligible impact determination can be made), only that the taking be reduced to the lowest level practicable." Practicality, expediency, and economics are not the basis for the NMFS mandate. In a later response, while NMFS noted that "the 180 dB isopleth is the distance that is most practicable for reducing potential impacts on marine mammals to the lowest level", CSI notes that this is a preliminary determination, and sincerely urges NMFS to reconsider. Otherwise, it is inescapable that the fundamental rationale for NMFS accepting the FEIS 180 dB mitigation threshold may be based primarily on the Navy's needs. This supports allegations concerning collusion between the Navy and NMFS, the acceptance of the inadequate FEIS, the reliance on scientists associated with the LFA or Navy, and unsubstantiated assertions in the face of inadequate data.

FEIS ASSUMPTIONS:
The MMC commented that the curve used in the FEIS Single Ping Equivalent (SPE) Risk Assessment may not be valid, and is unverifiable. NMFS, however, accepts the curve as one of the hypothetical assumptions the FEIS develops in support of the 180 dB criterion. The FEIS's Risk Function SPE curve begins at zero at an RL of 120dB, and extends to 95% at 180dB. It assumes that 50% of the vulnerable animals are injured at 165 dB. Why is it acceptable to mitigate only after 95% of all exposed animals are injured? Perhaps because the 165 dB isopleth encompasses an enormous area, many square kilometers that may contain a significant percentage of any population, especially during behaviors significant to survival or reproduction. If 50% of the animals exposed to 165dB are at risk of injury, why isn't at least this mitigation level more in keeping with the NMFS mandate? 50% of the animals in an area of many square kilometers is likely to be a much greater number than 95% of the animals within a kilometer.

LACK OF SCIENTIFIC SUBSTANIATION:
A RL of 180 dB as the appropriate threshold of mitigations for the LFA source is not substantiated, and is not scientifically or legally defensible. The assertions in the EIS that it was affirmed by data, workshop conclusions, or the agreement of all associated experts are wrong. The 180 dB decision is based on opinions and unverified data. Transcripts of the opinions, or written statements or affidavits of supporting advisors have not been made available for review. CSI questions whether the declared consensus of experts used to substantiate the 180 dB level can itself be substantiated by all those said to have participated. Although the LFA-advising scientists are unnamed, the organization affiliations correspond to many of the scientists known to have advised NMFS on the same question, including Drs. Bowles, Ketten, Ridgway, Schusterman, Thomas, and Tyack. CSI challenges NMFS to prove that the experts agreed that 180 dB was an appropriate threshold of mitigation for the LFA source, based on scientific evidence of biologically important impacts rather than Navy needs or mitigation potentials.

Many experts have criticized the Scientific Research Program (SRP). As above, CSI requests that our previous criticisms and questions on the SRP still stand, as they have not been answered. Some critiques are that the projects were very short, did not focus on the species most

likely to be effected, and did not measure enough behaviors that the FEIS and NMFS consider to be biologically significant.

LACK OF SUBSTANTIATION FROM WORKSHOPS:
The FEIS also states that the 180 dB criterion was developed from three workshops. On behalf of CSI, I have attended at least 19 workshops, conferences and meetings on human noise in the oceans since 1996, and CSI was, at least while it served the Navy, designated one of four environmental organization "stakeholders" in the LFA process. From personal witness and written records I know that the several scientific workshops referenced to bolster FEIS declarations were misrepresented, or comments taken out of context, to create a perspective supportive if FEIS assertions. Prior to issuing the LOA and any rulemaking NMFS should publicly clarify or verify the conclusions from these sources as applies to the LFA.

CSI requests specifically that NMFS certify in some reviewable form that the 180 dB criterion is specifically supported by the following workshops:

High Energy Seismic Survey Team Workshop, June 1997 (HESS).
CSI challenges NMFS to provide any discussion or conclusion from this workshop that considers a RL of 180 dB from a 6-100 second, 100-500 Hz source an appropriate starting point for mitigations. The discussion did accept a value of 180 dB for seismic sources (190 dB for pinnipeds). Experts agree that a seismic source is impulse noise, with high-rise, short-duration signals (<1 sec). Although the FEIS uses an obscure and ill-defined definition of the LFA as an "intermediate duration source" the LFA is a continuous source. By general expert consensus a continuous source may have the same potential impact as an impulse source 5-10dB louder. One factor is an animal's auditory integration time. The 180 dB values expressed in the HESS report should not have been misappropriated by the FEIS, and cannot be used by NMFS.

Office of Naval Research Workshop on the Effects of Man-Made Noise on the Marine Environment, February 1998 (ONR).
This workshop produced no conclusion or recommendation relating to a 180 dB criterion, but did say: "This group did not discuss specific criteria under which mitigation would be desirable in order to avoid deleterious effects on marine mammals." Indeed, participants expressed the need to avoid the "one number fits all" solution. A few examples of further comments or conclusions that disagree with FEIS statements include: "There are simply too many structural and functional differences between marine mammal and land mammal ears to assume that acoustic trauma effects are isomorphic between the two groups." "Mammal ears are protected generally from self-generated sounds by both intervening tissues (head shadow and impedance mismatches) as well as active mechanisms (eardrum and ossicular tensors). Arguments that marine mammals can tolerate higher intensities simply because of their size and tissue densities are also not persuasive."

NMFS Office of Protected Resources Workshop on Acoustic Criteria, September 1998 (NMFS).
According to NMFS, based on information provided at two public workshops (HESS Workshop, June 12-13, 1997, NMFS Acoustic Criteria Workshop, September, 1998), "180 dB is the level above which scientists caution a PTS injury has the potential to occur in marine mammals". This is only clever word usage. It does not support the 180 dB mitigation threshold as the most appropriate for the LFA. Participants were specifically asked to discuss whether a 180 dB mitigation threshold was appropriate. Uncomfortable with a lack of useful data, they were simply unable to agree with that definition. Any consensus that implies otherwise must present statements by all the participants that they were supportive of that assertion.

On the issue of appropriate research, the NMFS workshop discussed: "A central question about animal reactions to anthropogenic noise is whether its negative impacts are biologically significant, as defined above. It is relatively easy to show that an animal reacts to a sound, but difficult to show that this reaction correlates with reduced fitness (fitness includes, but is not limited to, measures of survival because animals must survive to be able to reproduce)." "Simply

measuring a change in behavior following a sound is not sufficient. Behavioral states have a natural rate of change against which a response to a sound must be compared. Well-controlled data collection procedures are needed to separate noise induced effects from observed changes in behavior that merely coincide with a given acoustic event. For example, behaviors associated with nursing, foraging, mating, migrating, are most likely to have an impact on survival and reproductive success." "The negative responses animals make to sound have not been well documented." These comments reflect poorly on the LFA's Scientific Research Program (SRP).

Current research is insufficient for a prudent and objective assessment of risk to marine animals from anthropogenic noise. The Marine Mammal Commission, the National Research Council, the HESS panel and many experts categorically deny that science can yet provide adequate data to determine the specific characteristics or level of anthropogenic noise that will cause biologically significant impacts. The MMC and many other commenters noted that there were serious flaws in the underlying assumptions from the SRP upon which the FEIS is based. For example, "the Navy acknowledges that there are no LFS SRP data concerning the possible responses of representative cetaceans to LF sound above 155dB" (FEIS: 10-117). The MMC commented, to the DEIS, that "(t)he rationale for concluding that animals would not respond differently to exposure levels between 155 and 180dB is not evident and should be explained. The FEIS does not. Phase III never used the LFA at full power, kept source levels between 180 and 203dB, explained that it was difficult to get consistent RLs on focal animals, and yet SRP Phase III lumped all responses to RL's of 120 to 155dB as if equal. The results from the SRP have yet to survive the peer review process.

RESONANCE:
The LFA process has stimulated considerable attention by concerned experts, with ensuing benefits to human noise impact research and management. Perhaps the most significant is the discussion and hypothesis of resonance initiated by Balcomb. CSI has since worked with cetologists, bioacousticians, physicists, and anatomists to examine the hypothesis: Can the LFA source stimulate resonance sufficient to cause serious injury in marine animals? Without question it can.

Perhaps because the actual LFA asset was not a factor in the Bahamas stranding, as described in Balcomb's letter, the FEIS and perhaps NMFS seem to ignore all correlations between LFA frequencies and the conditions for resonance in marine animals. Because of the potential for serious injury at much lower RLs than 180 dB, they must be addressed by NMFS prior to issuing the LOA or related rules.

FEIS authors and advisors were aware of the resonance factor. Resonance and other non-auditory impact potentials were discussed at the ONR workshop: "Frequencies that result in resonance of the bronchopulmonary tree may also have a significant impact on the health of humans or marine animals." The two lung-frequency-depth models discussed predicted opposite results, and did not apply directly to marine mammals, but the conclusion was: "Clearly, if the lung resonance changes as a function of depth then as depth changes, the frequency function for damage risk threshold will need to be adjusted." "Lung effects for marine animals are more complex." On fish, the ONR workshop stated: "No studies have looked at the long-term or repetition effects of sub lethal blasts on these fish or the possibility of resonance for continuous signals interfering with sound production of the swim bladder for reproduction rituals or warning of predators."

Not only was this ONR discussion of resonance ignored in the FEIS, but also the correlation between the findings of the NATO SACLANTCEN Bioacoustics Panel and LFA frequencies was dismissed. The Minnaert and Andreeva / Barham theoretical models for calculations of the resonant frequencies of gas bubbles were ignored in the FEIS, as were communications from a scientist within NOSC (SPAWAR; Space and Naval Warfare Systems Command) on the subject. A Navy letter on resonance, "Interim Guidance for Operation of Low Frequency Underwater

effects on gaseous bubbles was not extended to marine animals, perhaps because the letter referenced human divers. "Draft NSMRL Technical Report: Summary Report on the Bioeffects of low frequency water borne sound" is missing from the FEIS, when, from the title alone, it appears to hold information pertinent to this topic.

To enunciate that resonance within marine animals from the LFA can result in serious injury and death, CSI includes in this LOA comment the contributions of several scientists who have shared their information with us. Some declined to submit a personal comment of their own. It is unfortunate that professionals would feel constrained to present their theories or information formally. Yet, it is very important that the following information not be misattributed.

Expert comments CSI has received on resonance applicable to the LFA include:

- Resonance is a threat at RLs much lower than that which may produce irreversible auditory trauma.
- The concept of an air-space resonance requires that air be enclosed in a cavity. The volume of the cavity is more important than its shape in determining the resonance frequency.
- Assuming the LFA sound is a linear propagating wave the principle of superposition applies and the response at each frequency is uncoupled to other frequencies.
- The fundamental frequency of a gas volume is that frequency at which it is most susceptible to excitation.
- The resonant bubble frequency depends on pressure and radius.
-Although many resonance effects depend on wavelength, air-space resonance does not. Because the wavelengths of the LFA signals are long (15 - 3 m) compared to the potential cavity sizes, the direction of the wave compared to the cavity is not important, unless there is some shadowing effect from a large structure near the cavity at some angles.
- The theory considers a pressure, which increases and decreases uniformly all around the cavity at the frequency of the sound wave.
- Resonance occurs in all structures, spherical or not. Small deviations from a spherical cavity can be tolerated. They result in secondary resonance at harmonics of the resonance frequency.
- Calculations for resonance in spherical bubbles become more complicated with irregular, conforming air spaces within living marine animals, and must include factors for compression during dives and ascents, and liquid or tissue-supported micro-bubbles within the larger cavity, similar to foam.
- Cavity-surrounding tissue that can support shear forces will also modify the resonant frequency and provide dissipative mechanisms via shear-wave conversion, viscosity and heat conduction.
- The shear modulus of whale flesh may vary. Current values appear use the approximate shear modulus for fish flesh.
- Calculations for the specific depth and frequency at which specific species, and even age and size classes, are most vulnerable to destructive resonance-induced sheer forces can be simplified by developing a generic table correlating "bubble" size, excitation frequency within the LFA range, and theoretical sheer forces.
- The acceleration of the cavity walls will cause shear forces in tissue that support it. Water does not support shear forces and can act as a lubricant to fill spaces and move around to reduce pressure gradients in more rigid tissue matrices.
- Lung tissue, the focus of many comments, consists of many very small cavities distributed through an almost homogeneous medium. Lung tissue should be treated as a shaped collective bubble medium with shear properties. Collective bubbles can resonate at much lower frequencies than individual bubbles within the mass, but there is a resonant collective oscillation that corresponds to the oscillation of the entire mass with the mean density associated with the tissue-bubble mixture.
- The tissue/air mixture in any space lowers the resonant frequency, compared to an all-air bubble. Rib cage rigidity may prevent the lungs reducing in volume as much as would be due for a free bubble, also reducing resonant frequency at depth and perhaps raising it at atmospheric pressure.

- A crude model of lungs as a spherical collection of air and soft tissue with between 5-95% air content and 6 liters capacity (adult male human, but probably equal to various cetacean species) produces resonance frequencies of ~80-180 Hz at 10m depth. These values rise to 140-320 Hz at 50m depth.
- Another calculation for a lung volume of about 4 liters, a spherical bubble of equivalent volume would have a radius of about 0.01 m. This would resonate at about 320 Hz at the surface, and 500 Hz at 20 m depth.
- From another perspective the radius of a bubble resonant at 100 Hz would be 32.8 cm at 100m. The air cavity volume would be 0.15 m3. At 500 Hz, the radius would be 6.6 cm, and volume 0.011 m3 at 100m depth.
- To complicate the issue, and demonstrate the current need for research there are also complex models of the lungs available within the acoustic community that predict the resonant frequency decreases with depth, contrary to phenomenological expectations.

Anatomical considerations include:

- Cetaceans have airspaces which, within any species-specific "normal" depth range, correspond to the characteristics of spaces vulnerable to LFA-frequency-induced resonance. Anatomists will need specific research to detail this point more fully, but initial calculations are alarming: Balcomb calculated the peak resonance of a beaked whale's individual pterygoid sacs and the laryngeal airspace at 290Hz at 500m depth.
- The point is that the lungs may not be the airspace most vulnerable to resonance from the LFA source, and all spaces thought to exist within a cetacean's dive range must be reviewed.
- Dimensions of vulnerable airspaces are species and condition specific. Little data is available. Some data, such as the approximations derived from pooled data on fin and blue whales, don't take into account the volume occupied by soft tissues lining the bony nares. The "best available" data for a 21m blue whale may be a simplified figure where the lungs contain 2000 liters of air as a "pliant membrane", plus 210 liters of air in another "pliant membrane", the laryngeal sac, plus 100 liters in the bony nares. However, these measures do not include data on the volume of air in the trachea, larynx, and pharyngeal spaces.
- Using spherical bubble calculations, resonance would occur in a bottlenose dolphin lung (3.25 liters) at ~34 m at 100 Hz., ~127 m at 300 Hz., and 245 m at 500 Hz.
- Beaked whale lung (136 liters) resonance depths are calculated as ~151 m at 100 Hz., ~564 m at 300 Hz., and ~1042 m at 500 Hz. Using 0.84 liters as the air space for a beaked whale's laryngeal sac resonance depths are ~74 meters at 300 Hz., and ~135 meters at 500 Hz.
- In dolphins, the collapsing rib cage is thought to correspond to collapsing the lung volume, placing all remaining air in the upper respiratory tract (larynx, nasopharynx, and nasal regions).
- Large whales' ribs do not have the same jointed anatomy. Perhaps the diaphragm can stretch more than in dolphins, or perhaps the abdomen can be "sucked" up into the caudal portion of the thorax. If the entire lung air volume (including interior tissues and blood) were collapsed the air may go into the laryngeal sac (or perhaps shunted back and forth during sound production between the laryngeal sac and the laryngeal lumen and contiguous nasopharynx). The laryngeal sac may be an "overpressure - under pressure" valve. As a soft walled sac it can easily expand or compress to accommodate the volume changes, while the laryngeal cartilages are not at risk of cracking with changes in volume dimensions. Large whales don't have nasal sacs and may not have pterygoid air sacs. The nasopharynx walls are soft, and thus may accommodate some gas volume. The ventral portion of the trachea near the larynx is incomplete, and perhaps this can accommodate expansion of the air sac into the trachea to shut off the connection to the lungs, like a ball valve. Because of rigid walls, the bony nares are a poor place to store air, unless their linings are blood-expandable tissues that fill the space to prevent volume changes from cracking the skull.
-The lungs, as a bubble-like resonator, are attached to the stiffer bronchial tubes and tracheae. These stiffer structures conduct the sound pressure from the lung volume to the stiff laryngeal and cranial air spaces. The two largest of these remaining airspaces (pterygoid sacs or sinuses) are bilaterally adjacent to the ear bones and the base of the brain (via the large foramen for the

oversize VIII cranial nerve). This area is soft compared to the stiffer bone enclosed volumes below it and will undergo larger displacements than the bone enclosed air cavities. An amplification via the Helmholtz resonance offer higher tissue displacement possibilities than bubble resonance alone does. This system of stiff cavities can be considered to be a Helmholtz resonator attached to the lungs bubble resonator. Everyone uses the bubble resonator analogy when discussing resonance effects on marine mammals because there are many unknowns in addressing the real and more complex coupled resonators. That is not to say that using Minnaert's equation does not give any answers as it certainly does. The coupled bubble resonant and Helmholtz resonant structures may be better able to explain the trauma observed. The many potential resonances that can be excited at various depths in different size marine mammals may explain the many traumas observed.

CSI urges NMFS to refuse the application from the U.S. Navy for, and not issue final regulations pertaining to, a "Letter of Authorization (LOA) for the take of small numbers of marine mammals by harassment incidental to Navy operations of the Surveillance Towed Array Sensor System (SURTASS) Low Frequency Active (LFA) Sonar". Thank you for this opportunity to express our concerns with the SURTASS LFA Letter of Authorization.

Sincerely,

William W. Rossiter
President